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The Effect of Coconut Shell Liquid Smoke Concentration and Drying Duration on the Chemical Characteristics and Organoleptic Properties of Analog Jerky

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A B S T R A C T

This study aims to determine the optimal treatment combination of coconut shell liquid smoke concentration and drying duration for the chemical and organoleptic characteristics of oyster mushroom and red bean analog jerky. This study employs a completely randomized design (CRD) with a two-factor factorial structure and three replications. Factor I: concentration of coconut shell liquid smoke (0%, 0.5%, and 1%) and Factor II: drying duration (5 hours, 6 hours, and 7 hours). The chemical data were examined using ANOVA and Duncan's Multiple Range Test (DMRT) to see if there were significant differences at a 5% level, while the taste and smell data were checked with the Friedman test at the same 5% level. The best results were found with a coconut shell liquid smoke concentration of 0.5% and a drying time of 6 hours, showing 12.48% moisture, 1.04% ash, 20.62% protein, and 10.96% fat, along with preference scores of 2.5 for color (dislike), 3.04 for aroma (like), 3.2 for taste (like), and 3.16 for texture (like).

Contribution to Sustainable Development Goals (SDGs):
SDG 3: Good Health and Well-Being
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. Research Background

Analog jerky is a product similar to analog meat. Meat analog, or can be referred to as alternative meat is a term for products that mimic and have conventional meat characteristics including texture, sensory appearance, color and taste [1]. This analogue jerky is made from plant-based ingredients that contain high protein, so it has a nutritional value similar to animal protein.

Generally, jerky is made from beef, chicken and fish. However, the rapid development of the current era makes the trend of a healthy lifestyle very attractive to the public so that awareness of the importance of a healthy diet is getting higher so that quite a lot of people turn into vegetarians. Vegetarianism is a diet or diet without animal side dishes with or without the use of animal-derived products such as milk, eggs and honey [2].

Analogue jerky made from oyster mushrooms and kidney beans can serve as an alternative source of protein for vegetarian communities. Oyster mushrooms are rich in fiber and red beans contain protein and are low in fat [3]. Research conducted by [4] on making analog jerky made from oyster mushrooms and red beans with a ratio of 100:0, 75:25, 50:50, 25:75 and 0:100, showed the best product in the treatment of oyster mushroom:red bean ratio (75:25) and 8 hours of drying time. However, the jerky has a taste, texture, and aroma that is less preferred by panellists because it lacks a distinctive aroma like commercial jerky; therefore, further research was carried out with the addition of liquid coconut shell smoke and variations in drying time. Coconut shell liquid smoke contains several compounds that contribute to flavor, texture and shelf life.

Liquid smoke is a product of combustion of organic materials, such as wood and coconut shells. Coconut shell liquid smoke can be used as a natural preservative in food that is safe for consumption, and can provide sensory characteristics to the

product, such as taste, color and distinctive aroma [5]. Drying time is one of the key factors that influence the success of jerky making, as it affects both the texture and shelf life of the jerky. This is because, during the drying process, free water in the material evaporates. Physically, products that undergo the drying process will have a hard and dry texture, as well as a darker colour, due to the reduction in water content [6].

1.2. Literature Review

Analogue meat or meat analogue is an artificial meat derived from vegetable protein, which has a shape, texture, colour, taste, and nutritional value similar to animal protein [7]. Diversification of processed jerky analog products can meet the needs of vegetarian consumers and offer high-protein and fiber products for people looking for alternatives to animal protein. The characteristics of good jerky include a texture that is acceptable to consumers, as noted in Ref. Specifically,. [8] jerky should have a soft and chewy t,ealong withre and a sweesavourysavory taste.

Plant-based ingredients that become analog jerky raw materials are oyster mushrooms and red beans. Oyster mushrooms (*Pleurotus ostreatus)* can be a food source that is rich in nutrients and has various health benefits. In 100 grams of fresh oyster mushrooms, contain 92.2% water, 1.9% protein, 0.1% fat and several minerals, such as calcium and phosphorus [9]. Red beans are included in the legume category; they have the potential to serve as a source of protein, vitamins, and minerals [10]. Protein and carbohydrates in kidney beans are quite high, so they can be a source of nutrition. Kidney beans also contain minerals, such as calcium, phosphorus and iron, vitamins A and B1 and bioactive components, such as flavonoids and phytosterols [11].

Liquid smoke is the result of a distillation or condensation process obtained through direct or indirect combustion of materials that contain lignin, cellulose, hemicellulose, and other carbon compounds [12]. The process of making liquid smoke involves several stages, namely pyrolysis, condensation, and redistillation. The pyrolysis method itself is the process of burning organic material with little or no oxygen [13]. The main compounds contained in liquid smoke include phenols, organic acids, and carbonyls, which are known to have antibacterial and antifungal activities [14]. Phenol compounds such as guaiacol, 4-methyl guaiacol, and 2,6-dimethoxy phenol play a role in giving smoke aroma to food products [15]. Meanwhile, carbonyl compounds in liquid smoke function as flavor, color, and aroma formers, consisting of aldehydes and ketones formed during the pyrolysis process [16].

1.3. Research Objective

This study aims to determine the effect of coconut shell liquid smoke concentration and drying time on the chemical and organoleptic characteristics of analog jerky and to determine the best treatment combination from these variations.

2. MATERIALS AND METHODS

2.1. Material

The materials used for making analogue jerky are oyster mushroom, red bean, garlic, brown sugar, coriander, pepper, salt, wheat flour, sodium alginate, calcium lactate, and coconut shell liquid smoke. The materials for analysis include water, HCl, NaOH, alcohol, zinc, chloroform, and methyl red indicator.

The tools used are chopper, digital scales, stainless bowls, oil paper, spoons, cutting boards and knives. The laboratory equipment used includes a Soxhlet apparatus, water bath, heater, cabinet dryer, analytical scales, desiccator, furnace, silica cup, measuring flask, test tube, Erlenmeyer flask, measuring cup, pipette, and tweezers.

2.2. Research Procedures

The study was conducted using a factorial Completely Randomized Design (CRD) that included two factors: (1) the concentration of coconut shell liquid smoke (0%, 0.5%, and 1%), and (2) the drying duration (5, 6, and 7 hours). The collected data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level. To further identify significant differences between treatment means, the Duncan's Multiple Range Test (DMRT) was employed at the same significance level. Sensory evaluation was carried out using a hedonic scale method to assess product characteristics, including colour, aroma, taste, and texture, by a panel of 25 semi-trained evaluators.

2.3. Making Analog Jerky

Mix oyster mushroom and red bean (75:25). Add other spices including 4 grams of garlic, 2 grams of coriander, 130 grams of brown sugar, 2 grams of salt, and 1 gram of pepper. Then mix with 18 grams of wheat flour, 0.5% sodium alginate, 0.5% calcium lactate, and liquid smoke (0%; 0.5%; 1%). After mixing, form the mixture on baking paper. Then, dry it in a cabinet dryer at a temperature of 60°C for a specified drying time (5 hours, 6 hours, or 7 hours).

3. RESULT AND DISCUSSION

3.1. Water Content

The results of the analysis of variance showed that the interaction between the concentration of coconut shell liquid smoke and drying time had a significant effect ($p \leq 0.05$) on the moisture content of analog jerky made from oyster mushrooms and red beans. Each treatment factor also has a significant impact ($p \leq 0.05$) on the moisture content of the product.

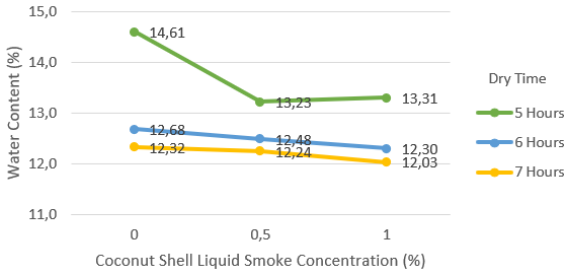

Figure 1. The relationship between the treatment of coconut shell liquid smoke concentration and drying time on the moisture content of analog jerky

Figure 1 shows that the higher the concentration of coconut shell liquid smoke and the longer the drying time, the lower the moisture content of analogue jerky. This is due to the drying process, which can evaporate the moisture content in the product. Following the statement of Ref. [17], the longer the drying time, the more the moisture content in the material will decrease. In addition, the content of phenol compounds in liquid smoke also affects the moisture content. Phenol has a hydroxyl group (-OH),

which is polar so that the interaction between phenol and water can form hydrogen bonds. However, the interaction of phenol and water does not significantly increase the moisture content of the product. According to [18] the interaction of phenol with water causes phenol to dissolve or escape from the material into the surrounding water. Additionally, the raw materials used can also impact the moisture content of food products.

3.2. Ash Content

The results of the analysis of variance showed that there was a significant interaction ($p \leq 0.05$) between the concentration of coconut shell liquid smoke and the duration of drying on the ash content of oyster mushroom and red bean analog jerky."In addition, each treatment also gave a significant effect on ash content.

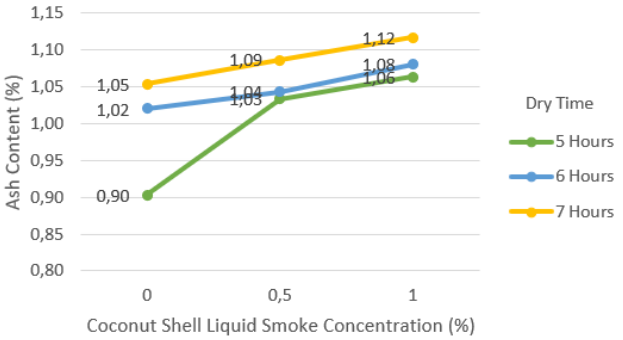

Figure 2. The relationship between the treatment of coconut shell liquid smoke concentration and drying time on the ash content of analog jerky

Figure 2. shows that the higher the concentration of coconut shell liquid smoke and the longer the drying time, the higher the ash content of jerky. This is because liquid smoke contains compounds that have the potential to be left behind during the processing process, such as phenols and organic acids. Liquid smoke contains various phenolic and carbonyl compounds derived from the pyrolysis of wood, these compounds contribute to solid residues when the material is burned. The longer the drying time, the lower the moisture content so that the mineral content in jerky becomes concentrated [19].

3.3. Protein Content

The analysis of variance results indicated that the protein content of oyster mushroom and red bean analogue jerky was significantly influenced by the concentration of coconut shell liquid smoke and the duration of drying ($p \leq 0.05$). Additionally, each treatment had a statistically significant impact on protein content.

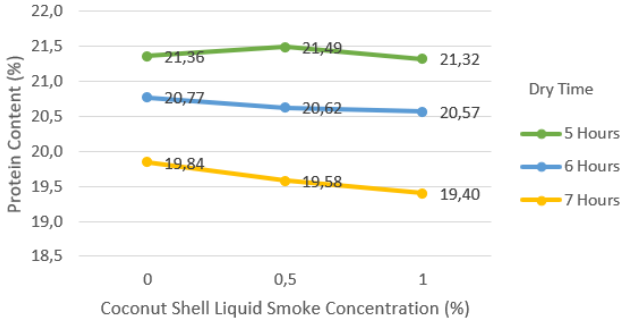

Figure 3. The relationship between the treatment of coconut shell liquid smoke concentration and drying time on the protein content of analog jerky

Figure 3 shows that the higher the concentration of coconut shell liquid smoke and the longer the drying time, the lower the protein content. The drying process can cause a decrease in protein content. The hot temperature during the drying process can also trigger the Maillard reaction, leading to a further reduction in protein content. As stated in Ref. [20], the longer the drying time, the lower the protein content produced, as this process destroys the amino acids that comprise the protein.

The addition of coconut shell liquid smoke can affect the protein content of analog jerky. Coconut shell liquid smoke does not contain protein, so the higher the concentration of coconut shell liquid smoke, the lower the protein content. Liquid smoke is the result of the pyrolysis of organic materials that produce phenol compounds, organic acids, and carbonyl compounds. Phenol compounds can interact with proteins and can change the structure and function of proteins. [21].

3.4. Fat Content.

The analysis of variance revealed that the amount of fat in oyster mushroom and red bean analogue jerky was significantly impacted by both the drying time and the concentration of coconut shell liquid smoke ($p \leq 0.05$). The fat content was also significantly impacted by each treatment.

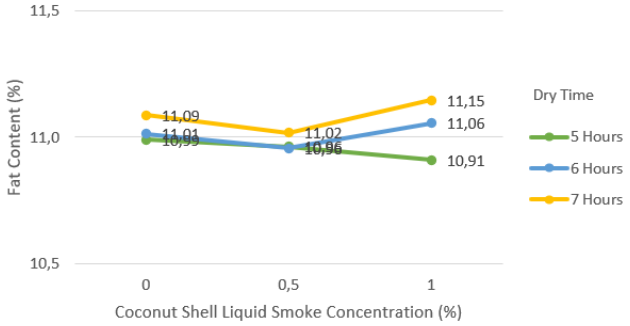

Figure 4. The relationship between the treatment of coconut shell liquid smoke concentration and drying time on the fat content of analog jerky

Figure 4 shows that the higher the concentration of coconut shell liquid smoke and the longer the drying time, the higher the fat content in the product. The increase in fat content can be attributed to the antioxidant activity present in coconut shell liquid smoke. One of the antioxidant compounds in coconut shell liquid smoke is phenol, this compound can reduce fat damage. According to the statement by [22], the phenol content in redestilat liquid smoke, at 3.39%, can inhibit fat oxidation damage. The addition of liquid smoke to food products can

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maintain the nutrition of analog jerky. The drying process can also affect the fat content of a product. When water is evaporated, solid components such as fat become concentrated in the product resulting in an increase in fat content [23].

3.5. Organoleptic Characteristic of Analogue Jerky

The quality of food products can be determined in three ways: physically, chemically, and sensorily. Consumer acceptance of food products is determined, in part, by their organoleptic quality. Organoleptic testing is conducted to determine consumer responses to the sensory attributes of products, such as color, aroma, taste, and texture.

Table 1. Organoleptic Test Result of Jerky Analog

Liquid Smoke Concentration (%)	Drying Duration (Hours)	Color	Aroma	Taste	Texture
0	5	3.2	2.8	2.92	2.68
	6	2.6	2.96	**2.56**	2.84
	7	2.88	2.92	2.72	2.52
0.5	5	2.32	3.28	2.92	2.88
	6	2.5	3.04	3.2	**3.16**
	7	3.04	3.24	2.68	2.56
1	5	3.12	3.4	2.6	2.44
	6	3.08	**3.44**	2.68	2.64
	7	**3.28**	3.36	2.72	2.76

Description: 1 (strongly dislike); 2 (dislike); 3 (somewhat like); 4 (like); 5 (strongly like).

The highest analog jerky color score, 3.28, was found in the treatment of 7 hours drying time and 1% liquid smoke concentration. The average color score in each treatment has a significant difference. This is caused by carbonyl compounds found in coconut shell liquid smoke. Carbonyl is produced from the cellulose pyrolysis process which affects the taste and color of smoked products. The color of smoked products is formed by the interaction between carbonyl compounds and amino acid groups on the surface of the material [24]. In addition, the process of drying and frying the jerky before serving also affects the color. During the cooking process, changes in appearance such as color occur due to the maillard reaction.

The highest analog jerky aroma score, 3.44, was found in the 6-hour drying time treatment and 1% liquid smoke concentration. The average aroma score in each treatment has a significant difference. This is due to the phenol compounds found in coconut shell liquid smoke."Phenol is the compound responsible for the formation of the characteristic aroma of smoke in smoked products. Phenols about sensory properties have a very real aroma on the product [25].

The highest analog jerky taste score, 2.56, was found in the 6-hour drying time treatment and 0% liquid smoke concentration. The average flavor score in each treatment did not show a significant difference. This is likely due to the basic spices used that create a relatively uniform flavor profile. This similarity can cause panelists to have difficulty in identifying differences in flavor that arise due to treatment. According to [26], volatile compounds in liquid smoke such as phenols have the potential to form distinctive flavor characteristics in food products. However, the effectiveness of these compounds' contribution to flavor perception is highly dependent on the composition of the product.

The highest analog jerky texture score, 3.16, was found in the treatment of 6 hours drying time and 0.5% liquid smoke concentration. The average texture score in each treatment has a significant difference. This is due to the drying time treatment. The longer the drying time, the dendeng will have a dry and hard texture. Physically, products that go through the drying process will have a hard and dry texture and a darker color change because the water content in the product has been reduced [27].

3.6. Determination of the best analog jerky treatment

The selection of the optimal formulation for oyster mushroom and red bean analog jerky, incorporating coconut shell liquid smoke and varying drying times, was based on comparisons of both chemical and organoleptic quality parameters. Chemical analysis included measurements of moisture content, ash content, fat content, and protein content, while organoleptic evaluation covered color, aroma, taste, and texture preferences. The best results were obtained with a formulation containing 0.5% liquid smoke and a drying time of 6 hours, yielding a moisture content of 12.48%, ash content of 1.04%, protein content of 20.62%, and fat content of 10.96%. In terms of sensory attributes, this formulation received preference scores of 2.5 for color (dislike), 3.04 for aroma (like), 3.2 for taste (like), and 3.16 for texture (like).

Table 2. Best Decision Analysis of Analog Beef jerky on the Treatment of Coconut Shell Liquid Smoke Concentration and Dryin Time

Treatment	Water (%)	Ash (%)	Protein (%)	Fat (%)	Color	Aroma	Taste	Texture
0%5h	14.61	0.90	21.36	10.99	3.2	2.8	2.92	2.68
0%6h	12.68	1.03	21.49	11.01	2.6	2.96	2.56	2.84
0%7h	12.32	1.06	21.32	11.09	2.88	2.92	2.72	2.52
0.5%5h	13.23	1.02	20.77	10.96	2.32	3.28	2.92	2.88
0.5%6h	12.48	1.04	20.62	10.96	2.5	3.04	3.2	3.16
0.5%7h	12.24	1.08	20.57	11.02	3.04	3.24	2.68	2.56
1%5h	13.31	1.05	19.84	10.91	3.12	3.4	2.6	2.44
1%6h	12.30	1.09	19.58	11.06	3.08	3.44	2.68	2.64
1%7h	12.03	1.12	19.40	11.15	3.28	3.36	2.72	2.76

4. CONCLUSION

The results showed that there was a significant interaction between the treatment of coconut shell liquid smoke concentration and drying time on moisture content, ash content, protein content, fat content, as well as color, aroma, and texture of analog jerky. However, the interaction between the two treatments did not have a significant effect on the taste of analog jerky. The best treatment was obtained at a coconut shell liquid smoke concentration of 0.5% and a drying time of 6 hours, with a moisture content of 12.48%, ash content of 1.04%, protein content of 20.62%, and fat content of 10.96%. Meanwhile, the organoleptic test results using the hedonic scale method showed a color value of 2.5; aroma of 3.04; taste of 3.2; and texture of 3.16.

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